

Program Overview

Relativistic Nuclear Collisions

Grazyna Odyniec

Nuclear Science Division

Lawrence Berkeley National Laboratory



Outline

1. Overview: Grazyna Odyniec (20)

Who we are

Our goals

Recent highlights

Near - term plans

Long - term plans

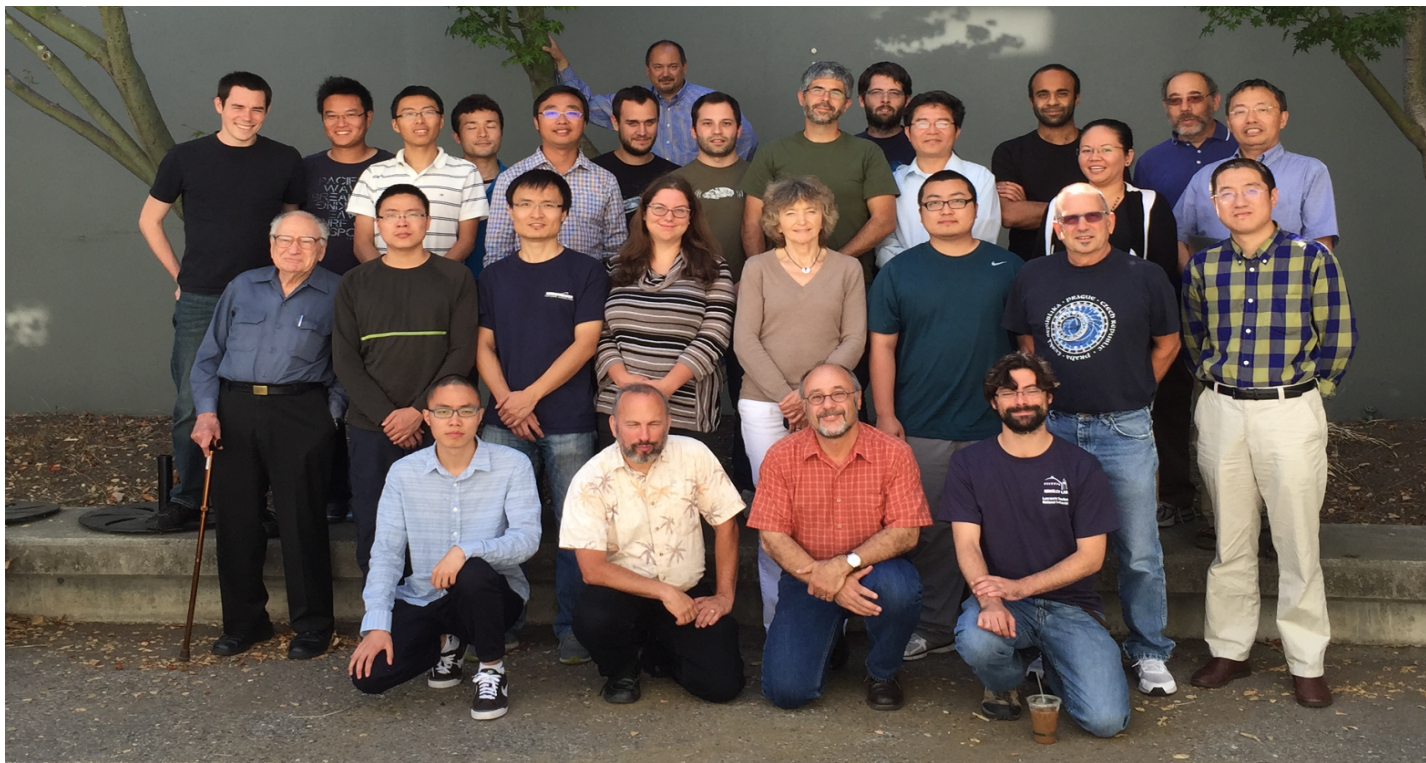
2. STAR Physics: Xin Dong (20)

3. Spin Physics and EIC: Ernst Sichtermann (20)

4. ALICE Physics: Constantin Loizides (20)

5. Instrumentation: Leo Greiner (20)

RNC Members 2012-2016



Top Row From Left: A. Schmah, H. Qiu, L. Ma, S. Mizuno, X. Luo, M. Simko, L. Greiner, A. Collu, G. Contin, J. Thaefer, F. Wang, M. Mustafa, L. Bonifacio, H. Matis, N. Xu

Second Row From Left: A. Poskanzer, G. Xie, J. Szornel, G. Odyniec, J. Zhang, J. Porter, X. Dong

Bottom Row From Left: J. Xu, S. Klein, P. Jacobs, M. Lomnitz



F. Bock



X. Chen



H. Ge



B. Jacak



C. Loizides



M. Ploskon



H.G. Ritter



Y. Shi



E. Sichtermann

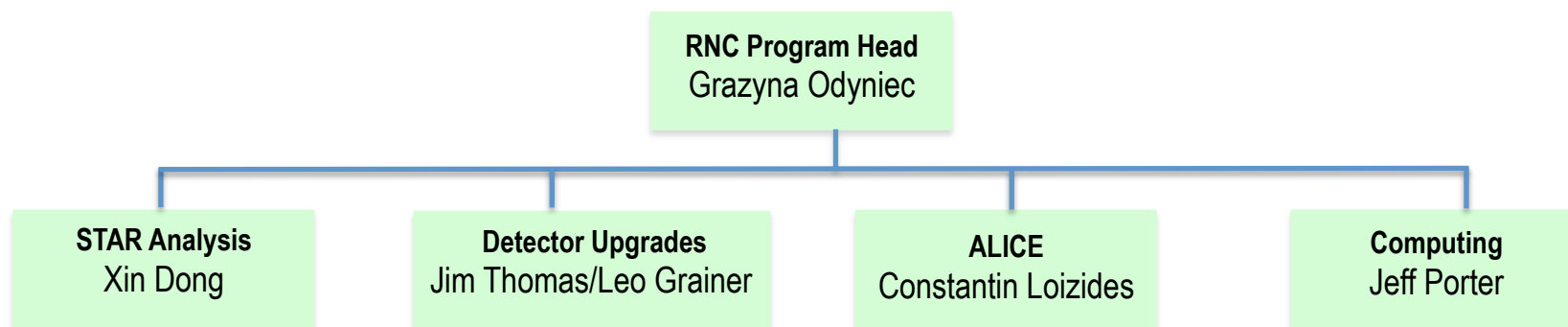


J. Thomas



H. Wieman

Who we are, RNC group



Career Staff:

Senior Staff Scientists: Jacak, Jacobs, Klein, Odyniec, Sichtermann, Xu

6

Staff Scientists: Dong, Greiner, Loizides, Ploskon, Thomas

5

Computer System Engineer: Porter

1

Short Term Staff:

Project Scientists: Contin (10/17), Schmah (5/17)

2

Postdocs: Collu, Zhang, Apadula, Radhakrishnan, Lai + 2 PD guests (Sun)

5 + 2

Students: Bock, Chen, Meehan, Oh, Szornel, Xie, Xu, Lomnitz

8

+ a sizable number of "external" students

Active retirees: Poskanzer, Ritter, Wieman, Matis

RNC Program Head: Peter Jacobs end of 5 years of appointment. THANKS, Peter !

National and International Leadership

National Advisory Committees

NSAC - P. Jacobs
NSAC Long Range Plan 2015 - P. Jacobs
APS Bonner Prize Comm. - P. Jacobs
LRP Implementation Subcomm. ("Tribble II") - P. Jacobs
NAS Board on Physics & Astronomy, chair - B. Jacak
RHIC&AGS Users' Executive Comm., chair-elect - J. Thomas
Chinese Academy of Science - N. Xu
National Academies' Committee on US-Based EIC Science
Assessment - E. Sichtermann

Facility Program Advisory Committees:

N. Xu - JINR, FAIR, Lanzhou (HI)
HG Ritter - FAIR
GSI Scientific Advisory Committee - B. Jacak

Editorial Board

P. Jacobs - EPL Letters
N. Xu - NPA, PPNP
S. Klein - Particle Data Group

Major Conference IAC:

QM: B. Jacak, P. Jacobs, N. Xu,
HP: X. Dong, B. Jacak, P. Jacobs, N. Xu
SQM: G. Odyniec, H. G. Ritter, N. Xu
PANIC: B. Jacak
CPOD: X. Dong, H. G. Ritter, N. Xu
PacSPIN 2013, 2015: E. Sichtermann
IniStages: M. Ploskon

Major Conference Program Committee

LHC Physics 2013 - M. Ploskon
QM 2014 - C. Loizides
DIS 2014 - E. Sichtermann
HP 2015 - P. Jacobs
QM 2017 - P. Jacobs, G. Odyniec
CHEP 2017 - J. Porter
DNP Program Committee - P. Jacobs

+ many smaller
conferences,
workshops, ...

Conference organization:

CPOD 2013 - H. G. Ritter et al.
IniStages 2014 - M. Ploskon, et al.
LHC UPC Workshop 2014 - S. Klein
SQM 2016 - N. Xu, et al.
EIC Users Group Meeting 2016 - B. Jacak et al.,
HP 2016 (LOC) - P. Jacobs
QM 2017 (LOC) - P. Jacobs, G. Odyniec
PacSPIN 2017 - E. Sichtermann
NT Workshop on UPCs & EIC 2017 - S. Klein

Collaboration Leadership

STAR:

E.Sichtermann – Deputy Spokesperson
J.Thomas – iTPC, Deputy Project Manager
N. Xu – BulkCorr Convener
G.Odyniec – BES Convener
A.Schmah – JettCorr Convener, EPD Leader
X.Dong – STAR Talk Committee
N.Xu – STAR Spokesperson (till 2014)
X.Dong – Physics Analysis Coordinator (till 2014)
J.Thomas – PI for HFT project at LBNL, SSD Sub-system Manager (2011-2016), Chair of STAR Talk Committee
L.Greiner- PXL Sub-system Manager
H.Matsui, H.Qiu, S.Shi, E.Sichtermann – PWG Conveners
E.Sichtermann – STAR Talk Committee

J.Porter – chair of PDSF Steering Committee

ALICE:

C.Loizides – co-chair of Editorial Board (since 2014)
B.Jacak, P.Jacobs – Editorial Board
J.Porter – ALICE-USA Computing Coordinator and Computing Project Manager
L.Greiner – ITS-USA Upgrade Project Manager
C.Loizides – Convener of photon PWG (till 2013)
M.Ploskon – Deputy Physics Coordinator (till 2015)

Prizes and Honors (since 2013)

2013:

Belvedere Professorship – Grazyna Odyniec

2015:

Bonner Prize – Howard Wieman

ACRS Hall of Fame – Barbara Jacak

2015 U.S Department of Energy Office of Science Graduate Student Research (SCGSR) – Michael Lomnitz

2016:

American Academy of Arts and Sciences – B.Jacak

2016 Goldhaber Prize - Kathryn Meehan

2016 U.S Department of Energy Office of Science Graduate Student Research (SCGSR) - Kathryn Meehan

2016 Wybitny Polak Award - Grazyna Odyniec

2017 Excellence in Physics Education Award (APS) - Howard Matis

Publication and talk counts in 2013 – to date

Publications where RNC people were PI or have had other substantial contribution:

STAR:

6 Physical Review Letters

7 Physical Review C

1 Physical Review D

3 Physics Letters B

1 Nature

$$\Sigma_{\text{total}}^{\text{papers}} = 18$$

$$\Sigma_{\text{total}}^{\text{citations}} = 908$$

Major Conferences:

Quark Matter 2015 – 12 talks

Quark Matter 2014 – 10 talks

Quark Matter 2012 – 6 talks

SQM 2016 (hosted) – 5 talks

SQM 2015 – 6 talks

SQM 2013 – 3 talks

HP 2016 – 3 talks

HP 2015 – 4 talks

HP 2012 – 3 talks

IniStages 2013 – 2 talks

IniStages 2014 – 5 talks

IniStages 2016 – 2 talks

ALICE:

1 Physical Review Letters

3 Physics Review C

9 Physics Letters B

1 JHEP

1 Eur.Physics J C

1 Journal of Modern Physics A

other papers:

43

$$\Sigma_{\text{total}}^{\text{papers}} = 16$$

$$\Sigma_{\text{total}}^{\text{citations}} = 836$$

7 Ph.D. Thesis in RNC:

Lomnitz (2016), Sun (2015), Sangaline (2015),

Guo (2014), Trzeciak (2013), Zhao (2013), Godoy (2013)

RNC Greatest hits 2013-2016

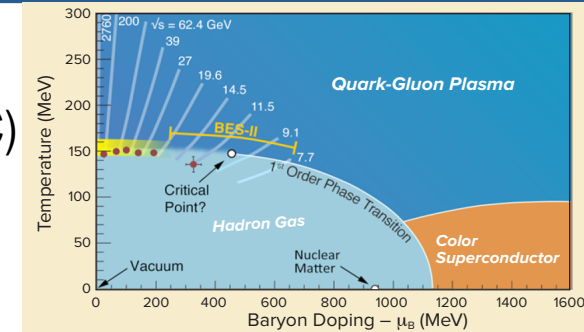
- *Long-range angular correlations on the near and away side in pp-Pb collisions at $\sqrt{s_{NN}}=5.02$ TeV;* Phys.Lett. B719 (2013) 29-41; **396 citations**
- *Energy dependence of moments of net-proton multiplicity distributions at RHIC;* Phys. Rev. Lett. 112 (2014) 32302; **165 citations**
- *Performance of the ALICE Experiment at the CERN LHC;* Int.J.Mod.Phys. A29 (2014) 1430044; **172 citations**
- *Observation of D^0 meson nuclear modifications in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV;* Phys. Rev. Lett. **113** (2014) 142301; **135 citations**
- *Electron Ion Collider: The Next QCD Frontier,* Eur.Phys.J.A 52 (2016) no.9, 268; **284 citations**
- *2014 Particle Data Group –* Chin.Phys. C38, 09001 (2014) - **5036 citations !**

What do we do – RNC Scientific Program

Quark Gluon Plasma, novel state of matter, discovered at RHIC (→ LHC)

Present focus of RNC:

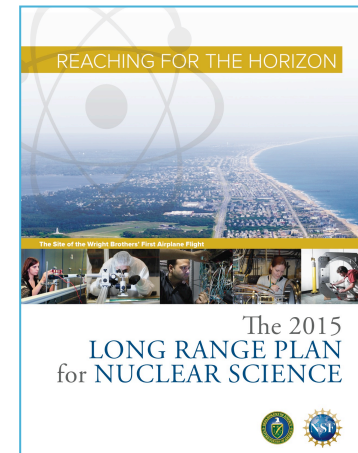
- explore and probe structure and dynamics of QGP:
 - QGP properties (= QCD in hot and dense medium), collective flow, jet quenching, heavy flavors, quarkonium suppression, real and virtual photons, thermal radiation, chiral symmetry restoration, ... (STAR@RHIC, ALICE@LHC)
- map and explore the QCD phase diagram - [a unique opportunity for US science](#)
 - Beam Energy Scan – change in beam energy to vary μ_B – search for Critical Point (CP), phase boundaries, onset of QGP, chiral symmetry restoration (STAR@RHIC)
- ultra-peripheral collisions – structure of heavy ions and meson physics
- spin structure of the nucleon
 - shed light on proton spin puzzle (STAR@RHIC)



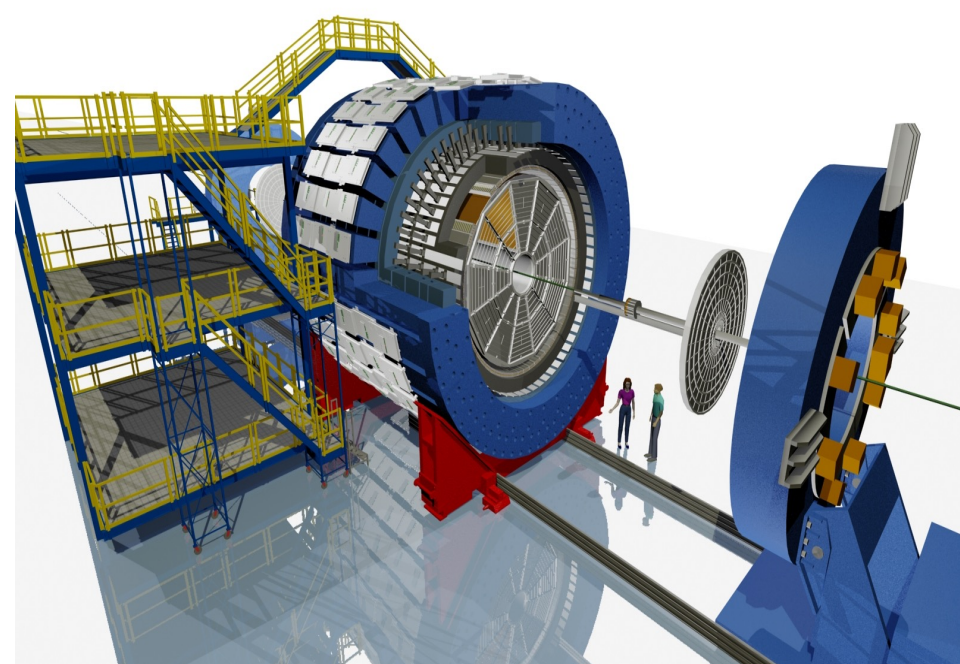
RNC program address recommendations 1 and 3 from LRP

RNC, as a National Laboratory group, is playing a major role in:

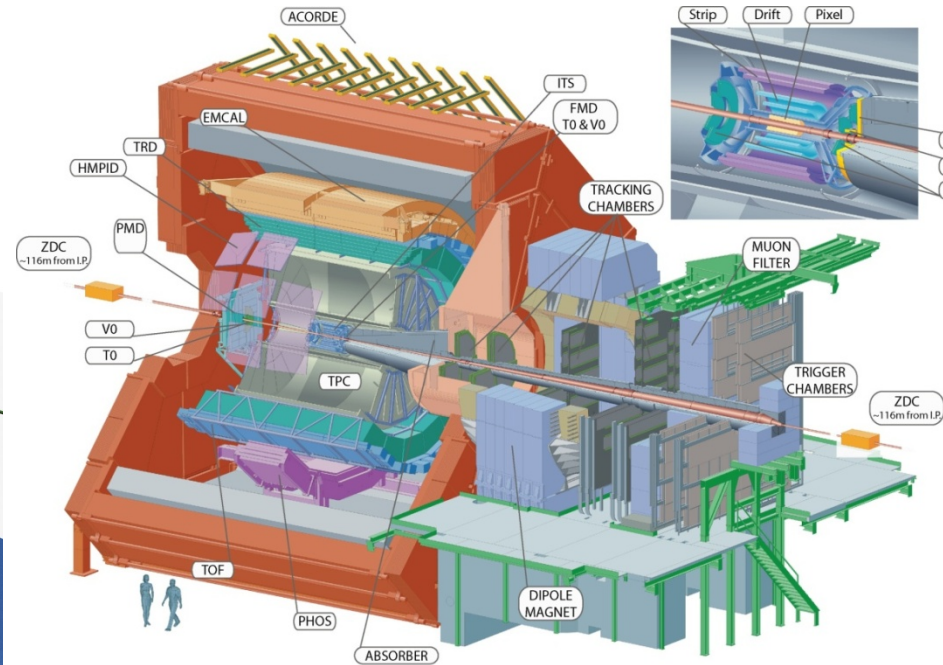
- national & international leadership in science, including initiating and leading major projects
- developing instrumentation (unique opportunities and facilities available at a National Lab)



Experiments, where we work



STAR@RHIC



ALICE@LHC

RNC in STAR: current activities and highlights

Heavy Ions:

talk by Xin Dong

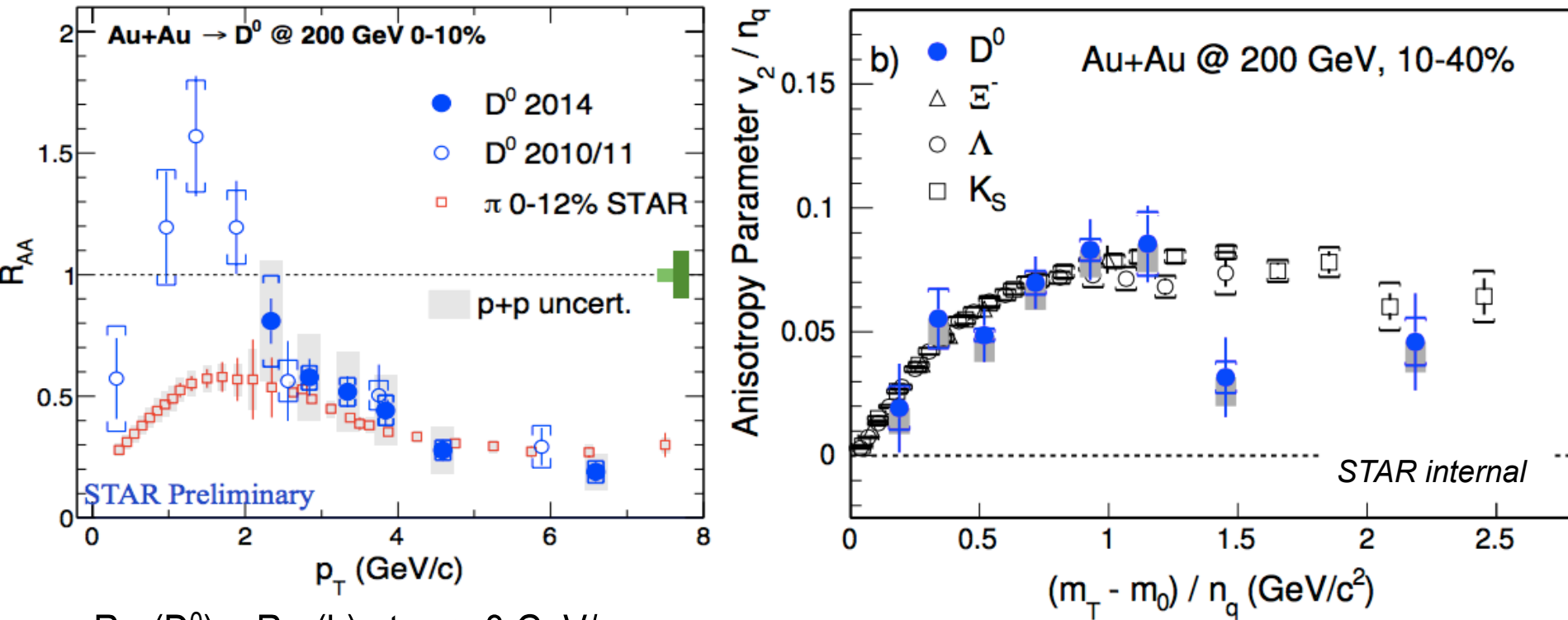
- commissioning and first analysis of HFT data (2014, 2015 and 2016)
- heavy flavor with HFT: direct reconstruction of $D^0 \rightarrow K \pi$, $c\tau \sim 120 \mu\text{m}$ ($\rightarrow v_2, R_{AA}$)
- v_2 of multi-strange baryon (including Ω^-) and ϕ meson
- completion of Beam Energy Scan Phase I – analysis includes final energy point at 14.5 GeV
- search for CP, analysis of high moments of net-proton, net-charge and net-kaon multiplicity distribution
- differential analysis of v_2 and breaking of Number of Constituent Quarks (NCQ) scaling at low energies
- di-electron measurements – show low mass enhancement at energies 19.6 – 200 GeV
- jet analysis, new measurements of jet production, structure, and scattering in the QGP
- high statistics study of dipion photoproduction from ρ^0 , ω and direct $\pi^+\pi^-$ and heavier resonances
- developing BES II Program + participating actively in upgrades for BES II (iTPC, EPD)

Spin structure of proton:

talk by Ernst Sichter

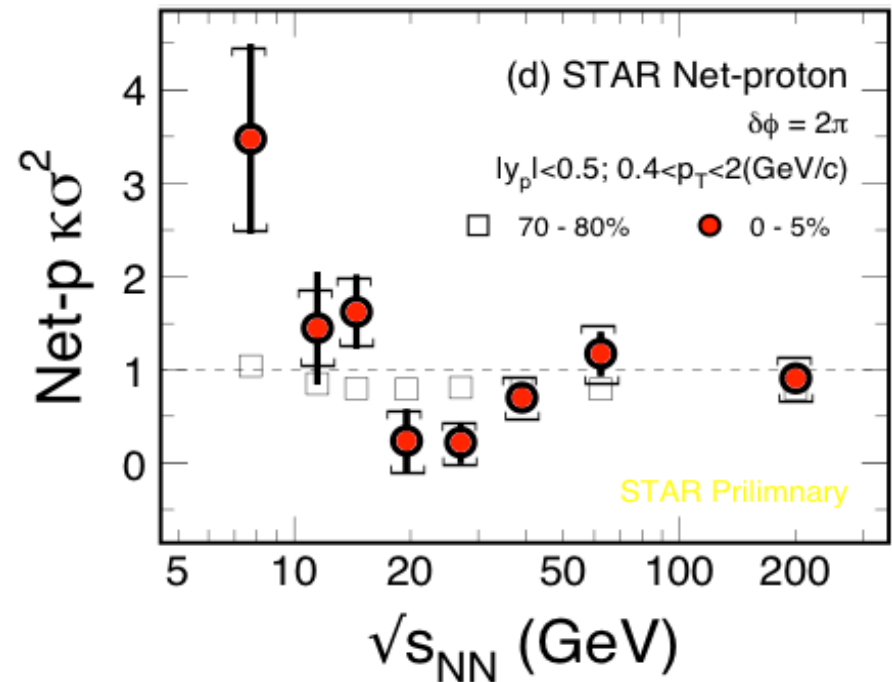
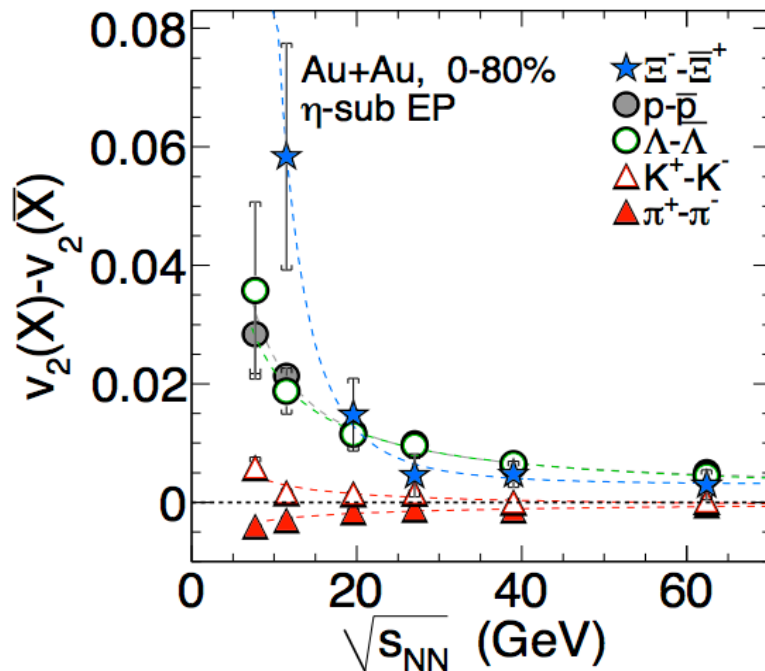
- $\Delta G(x)$
- quark and anti-quark helicities
- developing Cold-QCD Program for 2017-2023

PRL 113 (2014) 142301, QM15



- $R_{AA}(D^0) \sim R_{AA}(h)$ at $p_T > 3$ GeV/c
- v_2/n_q vs. $(m_T - m_0)/n_q$: $D^0 v_2 \sim$ light hadrons
- charm quarks lose significant energy in medium and they flow the same as light quarks

PRL 110 (2013) 142301, PRL 112 (2014) 032302, QM2015

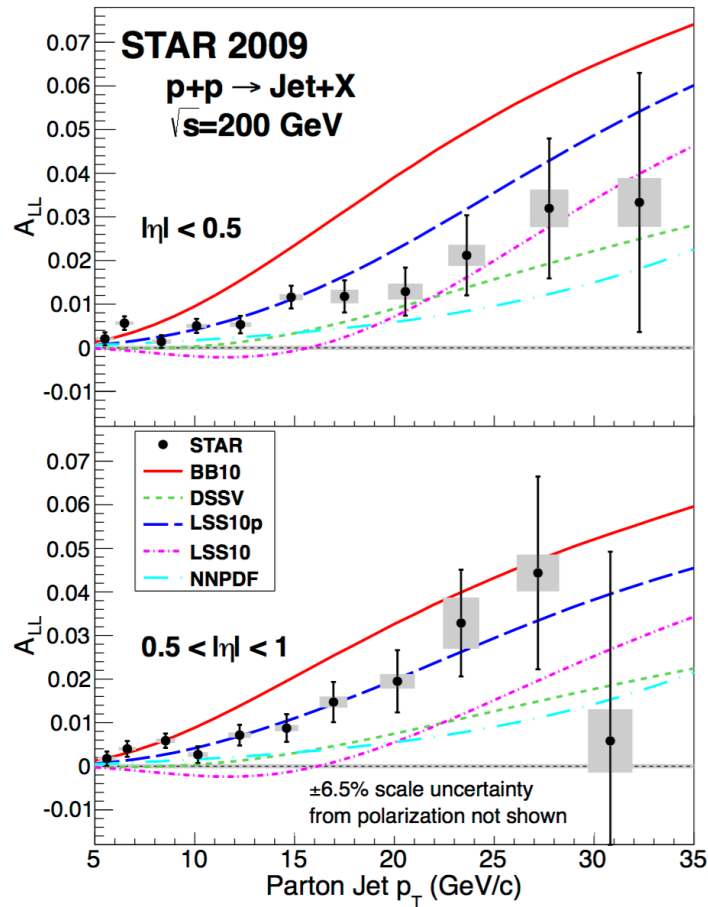


- Significant difference between baryon-antibaryon v_2 at lower energies (< 11.5 GeV)
 - Number of Constituent Quarks scaling between particles and anti-particles is broken
 - indication of turn-off of QGP signature below 11.5 GeV ?
 - Non-monotonic behavior observed in net-proton $\kappa^* \sigma^2$ vs. energy in central Au+Au collisions
 - connection to critical fluctuations ?
- preparing for Beam Energy Scan II for precision measurements at 7.7-20 GeV

Numerous RNC contributions to the gluon-polarization program
NSAC-milestone HP12

$$\int_{0.05}^1 \Delta g(x, Q^2 = 10 \text{ GeV}^2) dx \simeq 0.2\hbar$$

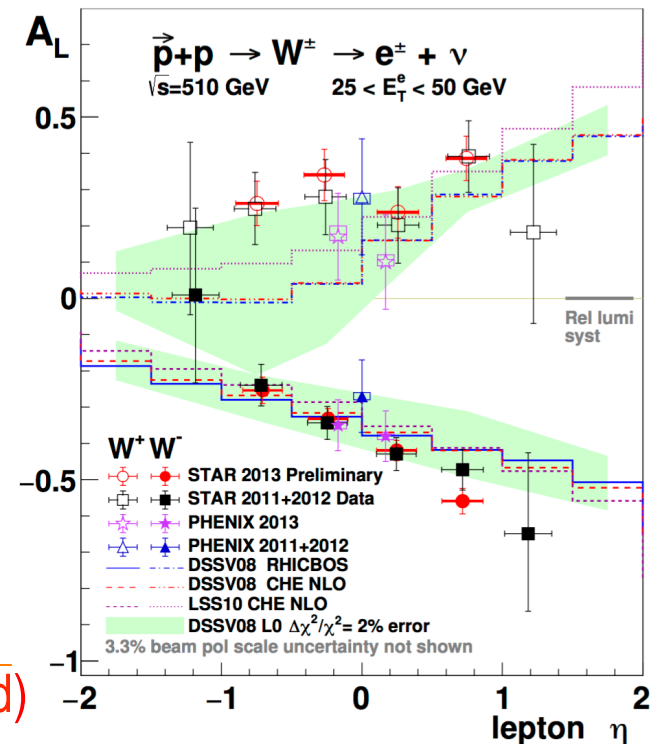
Fraction of proton spin carried by intrinsic spin of gluons:
 ΔG is non zero and positive



Most precise A_L measurement from RHIC

$$\Delta \bar{u} > \Delta \bar{d}, \text{ while } \bar{d} > \bar{u}$$

Spin carried by \bar{u} quark ($\Delta \bar{u}$) differs from that of \bar{d} quark ($\Delta \bar{d}$)



RNC in ALICE: current activities and highlights

Heavy Ions:

talk by Constantin Loizides

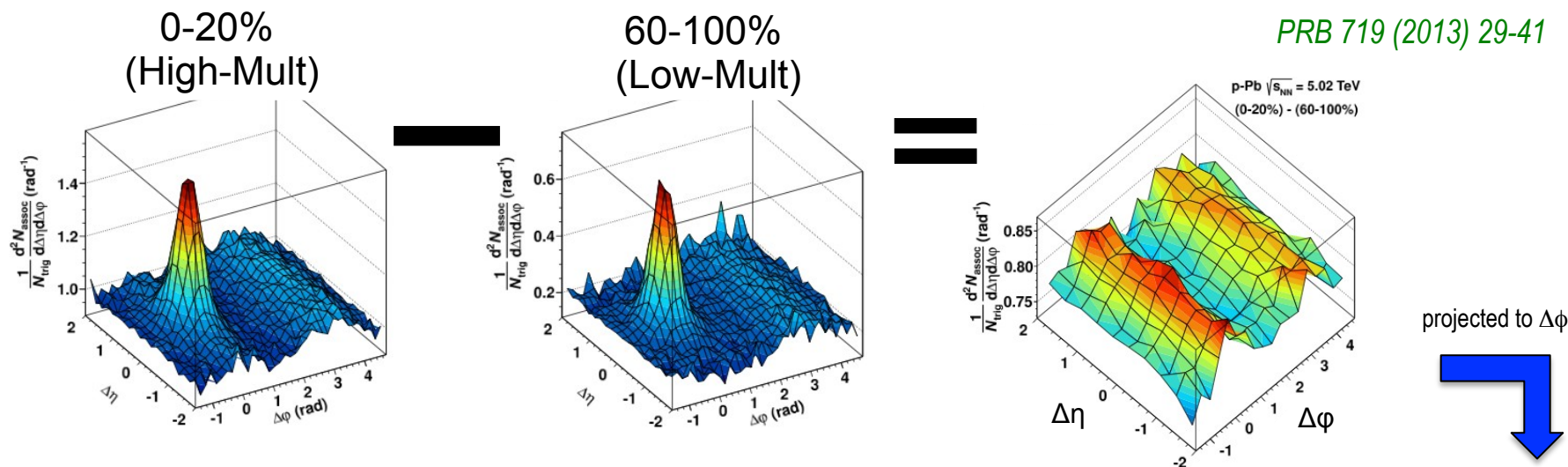
- commissioning and first analysis of EMCal/DCal data
- inclusive jet production in p+p and Pb+Pb
- first measurements of semi-inclusive hadron-jet distributions in Pb+Pb and p+p
- collective behavior in small system (p+Pb)
- jet quenching in small systems
- neutral meson and direct photon (low to intermediate p_t) analysis
- two particle correlations
- HF electrons at high p_t

ITS Upgrade:

talk by Leo Greiner

- next generation silicon vertex detector builds directly on pioneering development carried by RNC for STAR HFT

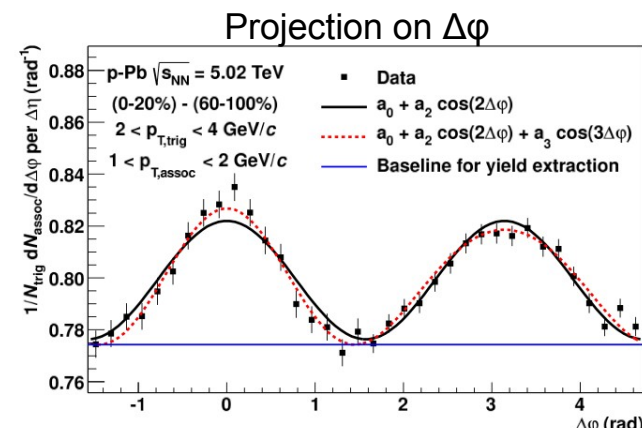
PRB 719 (2013) 29-41



p+Pb: yields of high multiplicity class – yields in low multiplicity class
 \rightarrow **double-ridge**

Fourier decomposition to obtain v_2 and v_3

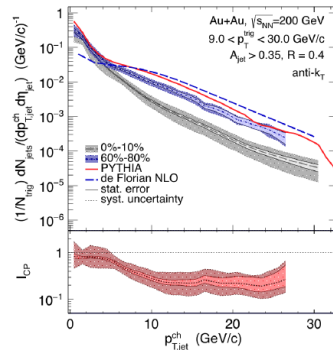
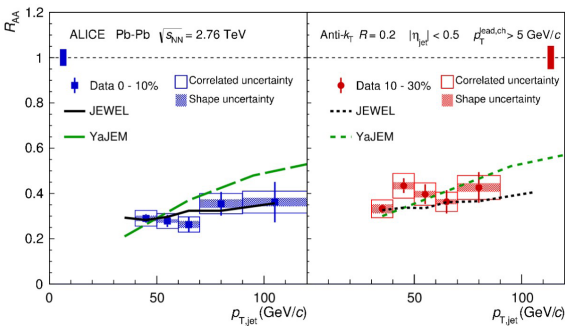
In PbPb explained by collective response to initial pressure gradient
 In pPb ? – perhaps GLASMA ?



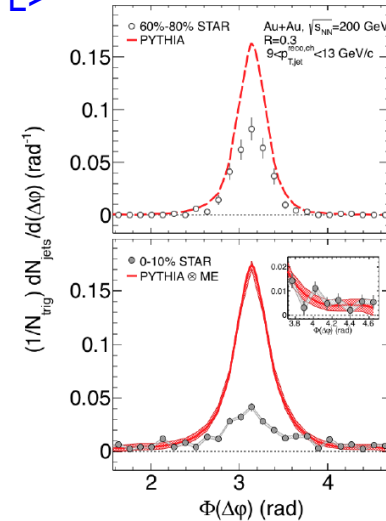
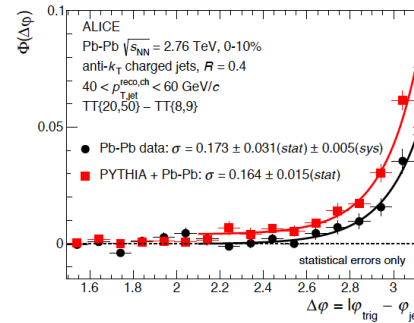
STAR/ALICE: Jet measurements at RHIC and LHC

STAR/ALICE: same instrumentation, same analysis techniques
 Goal: full jet range at both colliders, including low p_T^{jet} and large R
 (Semi)-inclusive observables: calculable perturbatively in vacuum

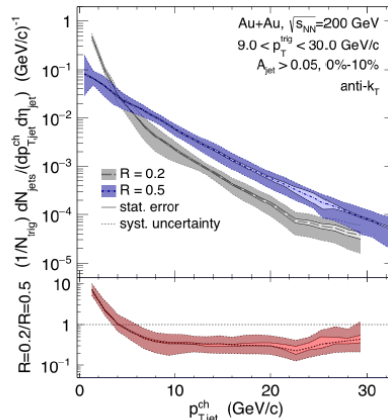
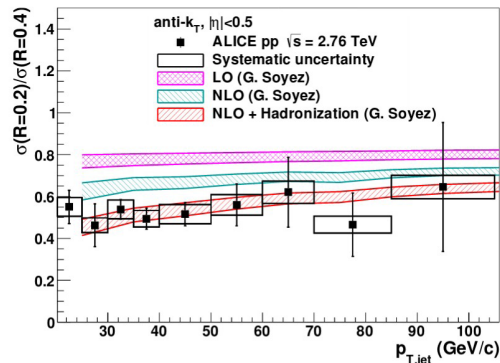
Jet yield suppression/quenching



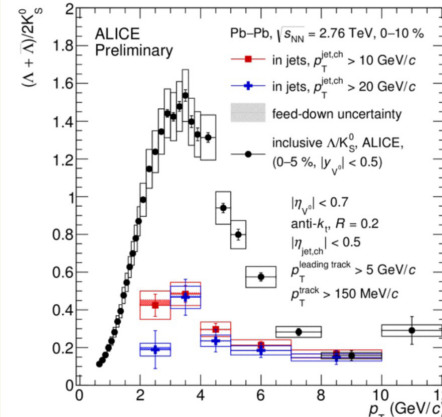
Moliere scattering in-medium
 Direct probe of $\langle q\hat{a}t^*L \rangle$



Jet shapes



Flavor in jets



talks by X. Dong
 & C. Loizides

Program evolution

past → *current* → *near future* → *long term future*

Physics:

→ Collectivity

flow measured at RHIC/ALICE → flow of HF, ϕ , Ξ , Ω , D^0 → flow of bottom (RHIC,LHC)

→ Jet quenching

hadrons → jets → precise jet structure and scattering in-medium → jet physics in EIC?

→ QCD Phase Structure

STAR BES-I → BES-II → “BES III” (large μ_B : fxt at STAR, CBM) ?

→ Photoproduction probes

STAR UPCs → EIC

→ Spin physics

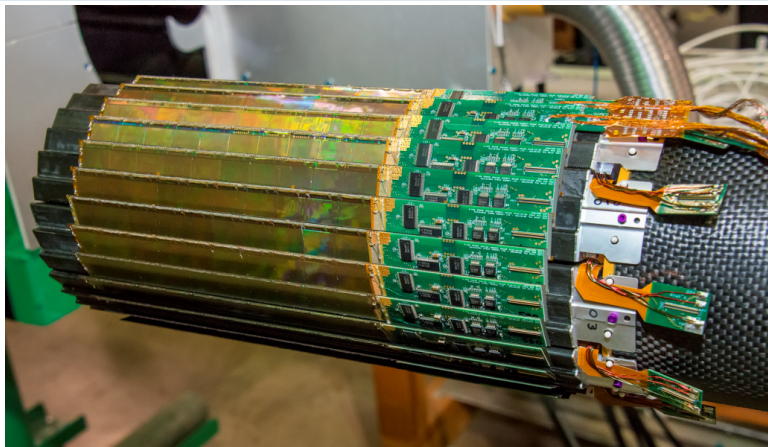
RHIC spin program → RHIC Cold QCD plan → EIC

Instrumentation:

→ MAPS vertex tracker

HFT → ITS → next generation MAPS vertex detector for RHIC (for bottom-hadrons) → EIC

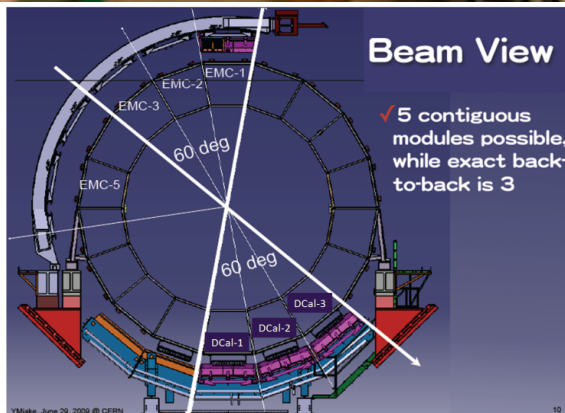
RNC Current Projects (2010-15)



MAPS Vertex Detector HFT for STAR

First application of Monolithic Active Pixel Sensors (MAPS) in a collider experiment. Detector originated and developed in LBNL, strong leadership and major technical & managerial responsibilities by RNC and LBNL engineering, completed in 2014, on time and under budget (14M project, 9M spent at LBNL)

talks by Xin Dong, Leo Greiner



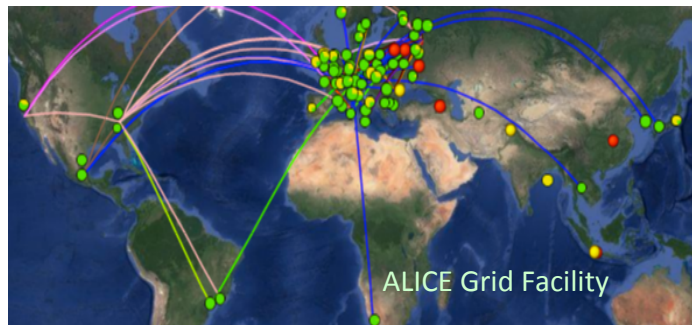
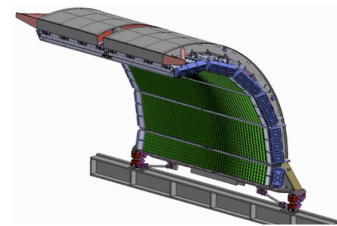
ALICE EMCal and DCal Projects

LBNL – Lead Laboratory for EMCal/Dcal projects

EMCal – completed in 2011 on time and under budget

DCal (second arm) installed in 2015

talk by Constantin Loizides



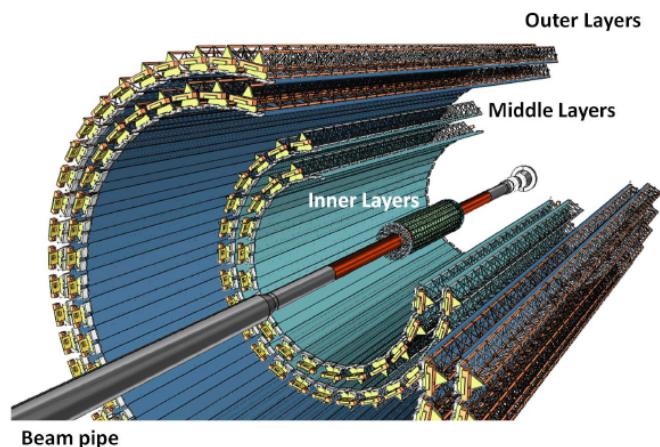
Computing at NERSC/PDSF

Shared facility for LBNL NP and HEP communities

Lead Laboratory for ALICE-USA Computing Project (TIER 2)

Second largest computing facility for STAR (~ TIER 1)

RNC Current Projects (2015-20)



MAPS ITS for ALICE

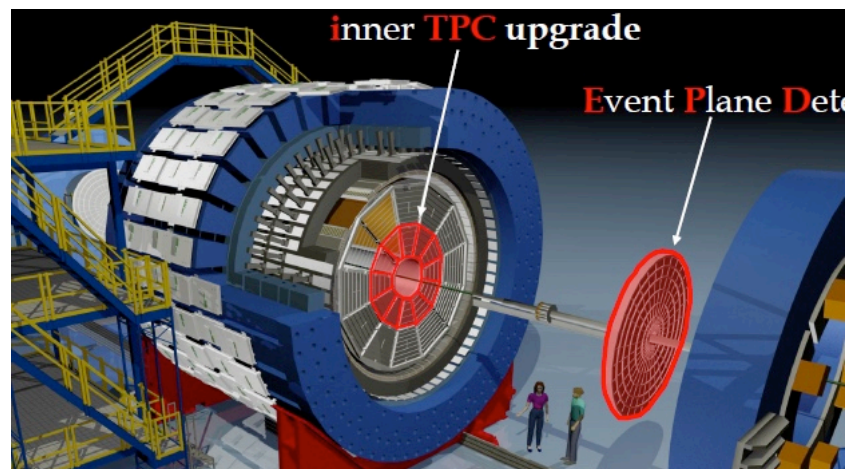
talk by Leo Greiner

LBNL – Lead Laboratory for ITS Project

Lead by RNC and Engineering

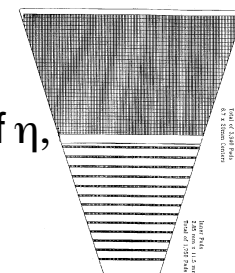
ITS-USA project leader Leo Greiner (RNC)

Build on our established capabilities for MAPS and composite materials, May 2015 - CD3 equivalent, total project cost ~ \$4 M



innerTPC (iTTPC) for STAR

replacement of inner sector of STAR TPC to provide continuing coverage and to extend range of η , 4.5 M project, 600 K will be spent at LBNL



Event Plane Detector (EPD) for STAR

new forward trigger and event-plane detector for BES II program
Initiated and lead by RNC

Computing

Development of software to migrate data processing for STAR and ALICE from PDSF to NERSC High Performance Computing

Under discussions: next generation MAPS vertex tracker @ RHIC

RNC Computing: PDSF



Data Intensive Cluster for Nuclear & Particle Physics Experiments

Operated by NERSC for LBNL NSD & Physics

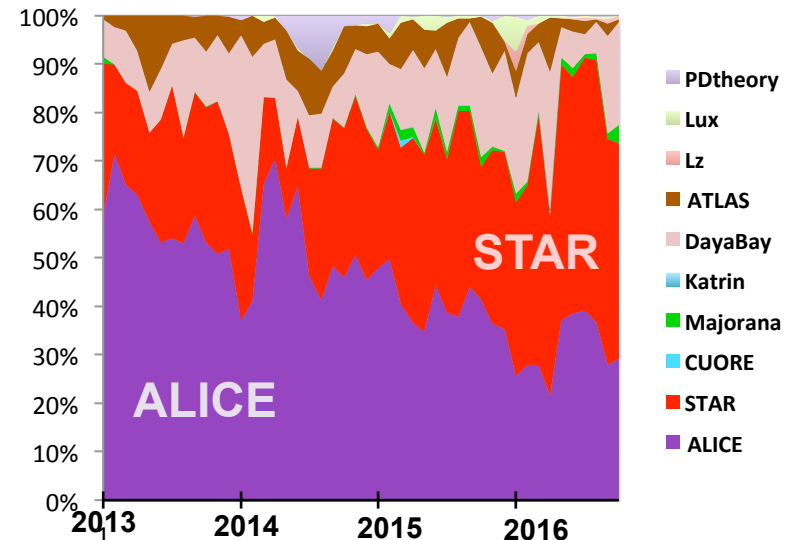
Science Divisions provide HW + 2 FTE

- Share of facility based on investment
- RNC provides 75% of FTE effort

NERSC provides 24x7 ops, space, util.

- Facility Features:
 - 2500+ CPU-cores & 3 PB of disk space
 - Multi-PB NERSC HPSS (tape) allocation
 - High bandwidth connection to ESNet

3+ Year PDSF Usage (%) by Group



STAR & ALICE combine for >75% of PDSF

ALICE & STAR use of PDSF

- STAR Simulation and Analysis Facility
 - Largest non-BNL facility available to all STAR members
 - RNC commitments:
 - NERSC PI, user access and account support
 - Software & simulation tools deployments
 - Site-level data management operations
- ALICE Grid Tier 2 Facility
 - Component of the ALICE-USA Computing Project to provide Grid-enabled storage & CPU resources to ALICE
 - Project managed at LBNL (J.Porter)
 - Paired with ORNL/CADES as distributed Tier 2 site
 - RNC commitments:
 - NERSC PI and ALICE Grid management support
 - Project manager & Computing Coordinator
 - POC for DOE Open Science Grid

STAR PDSF Resources		
Storage	XRootD disk	800 TB
	GPFS disk	400 TB
	HPSS tape	2000 TB
CPU	~1100 cores	10,000,000 CPU-hrs/yr

ALICE PDSF Resources		
Storage	Grid-enabled XRootD disk	900 TB
	GPFS disk	100 TB
CPU	~800 cores	7,000,000 CPU-hrs/yr



Goals in near term and midterm future

Near term (2017- 2020):

- STAR HI: - HFT/BES-I data analysis and BES II to explore phase diagram
→ to develop physics for 2021 - 2025 to complete RHIC mission
- complete HI jet measurements with high statistics
- STAR SPIN: - run 17 focused on Sivers' sign change (NSAC milestone HP13)
- ALICE: - heavy flavor in jets, high precision and statistics jet structure and jet- scattering measurements in medium, emphasis low to medium p_t jets

Midterm (2021 – 2025):

- contribute to heavy flavor measurements in RHIC (measure bottom-hadrons with high accuracy)
- sPHENIX will be the next large construction project at RHIC
 - work in progress on estimation of sPHENIX capabilities of measuring bottom-hadrons, di-electrons ($1 < m_{l-l_bar} < 3 \text{ GeV}/c^2$) and PID of proton for high moments analysis (C6, C8, and C10)
 - checking the theory expectation of smooth cross-over at vanishing μ_B
 - leads to future EIC detector beyond 2025-2030
- ALICE – present commitments are through LHC run 3
 - quantitative improvement with 10X more statistics (D^0 , B in jets, ...)
- RHIC Cold QCD (plan for 2017-23 requested by DOE)
- develop a significant part of EIC detector



Long-term plans: U.S. – based Electron Ion Collider

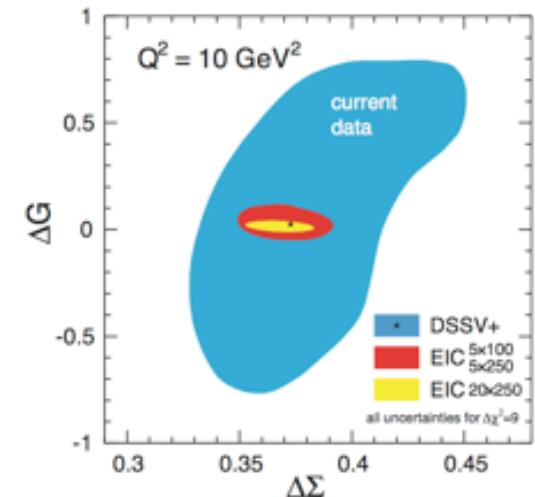
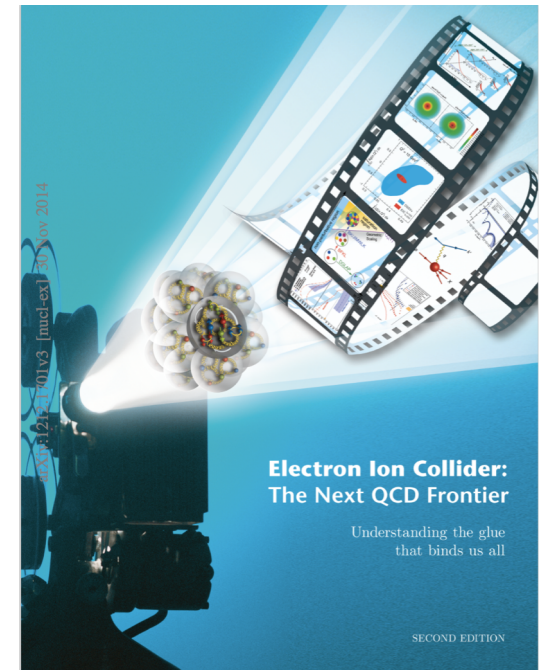
“Next big thing” in nuclear physics; highest priority for new construction in 2015 Long Range Plan

E.Sichtermann and F.Yuan were co-conveners for the EIC white-paper input to the 2015 LRP, S.Klein was co-author

RNC group now deepening its involvement in EIC physics, looking to play a major role in an EIC detector, subsequently engaged in R&D programs:

- generic EIC R&D program (E.Sichtermann/B.Jacak)
based on strengths in Si-based tracking
- LBNL-funded strategic initiative LDRD (S.Klein) to deepen RNC and Accelerator Division involvement in EIC

B.Jacak has initiated and leads formation of a an University of California Consortium, involving LBNL, 4 (so far) University of California campuses, Los Alamos and Livermore National Labs



Strategy

Building on the success we will push boundaries of knowledge in NP targeting highest potential for discoveries

Our core competence and strength :

- Scientific leadership
- Large scale projects : design, construction, operation, analysis
- Large collaborations: leadership and management experience
- “Know how” about high-tech detectors and advanced computing

As a National Laboratory group we have an access to resources (community of theorists, engineers, shops...) and we can use them successfully in big and complex project (see synergies slide)

→ RNC aims to hire additional detector scientist (replacement for H.Wieman)

Synergies

RNC ↔ NSD Theory Group, theorists from other institutions

- BES Program: QCD phase diagram and Critical Point search (BEST)
- Jets and jet quenching (JETSCAPE Collaboration)
- Spin and EIC physics (TMD Collaboration)

STAR ↔ ALICE

- Common physics goals, similar instrumentation
- Two-way flow of ideas, algorithms, interpretation
- Common computing issues and approaches
- Upgrades: ALICE ITS is a next generation of STAR HFT

RNC ↔ Engineering ↔ Physics Div.

- Electronics
- Composite materials
- Project management

RNC ↔ Computing

- transition from PDSF to NERSC HPC systems, tools development for data processing
 - data management tools
- these solutions are important for the entire field

Connection to universities: UCB, UCD, UCLA, CCNU/Wuhan, USTC/Hefei, SINAP/Shanghai, WUT/Warsaw, Kent State U

LDRD

2010-2013: C.Loizides et al., New approaches to direct photon measurements

outcome: preliminary isolated photon cross section in pp at 7 TeV using data-driven approach for isolation efficiency and photon purity.

2014-2015: M.Ploskon et al., Computing/analysis strategies for next-generation collider detectors

outcome: developed a new strategy and established working environment for massive computing needed for collider data processing using High-Performance Computing clusters at NERSC (Edison, Hopper and Cori). Successfully tested of ITS simulations.

2016: N.Xu et al., New generation low-mass-solid-state pixel detector

outcome: developed new trigger strategy for $B \rightarrow J/\psi$, $B \rightarrow D$ (using HFT data) developed plan for mechanical structure for MAPS vertex detector to adopt new fast chip (for future RHIC vertex detector)

2016 - E.Sitchtermann et al., LDRD for ALICE analysis and instrumentation of the EIC

outcome: ALICE photon analysis and conceptual design of barrel tracker for EIC

2017 - S.Klein et al., R&D towards an Electron-Ion Collider

expected outcome: exploration of possibilities of photonuclear physics at EIC, optimization of low-mass inner silicon tracker for EIC

essential for our future projects

Summary

- Vigorous program of research in Heavy Ion Physics in RHIC and LHC
 - aligned with national priorities

Short term:

Upgrades to STAR (iTPC, EPD) and ALICE (ITS) to enable new physics opportunities
followed by exploitation of current/near future investments and opportunities
RHIC BES, STAR HFT, ALICE EMCal/DCal, ALICE ITS, NERSC computing
Exploring new opportunities in HI physics with sPHENIX

Long term:

Involvement and leadership at EIC

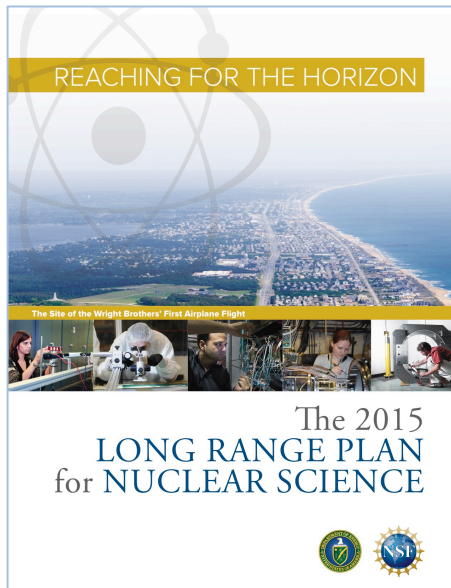
- Robust program of spin measurements with STAR
- Strong record of service to the HI and ME community and to the community at large
- Strong group of young people
 - training the next generation of physicists and detector experts

Back up slides

Timeline (current estimates)

	2016	2017	2018	2019	2020	2021	2022	2024+	
STAR	HFT + spin physics								
				BES II	BES II analysis				
	iTPC upgrade, EPD								
ALICE	data analysis		Shutdown 2						
	ITS construction			ITS install/commiss		ITS data taking ...			
EIC	LDRD					EIC R&D		EIC det ?	
sPH	MC/sim	MAPS vertex detector ?					data taking ?		

Goals: near term, midterm and long term

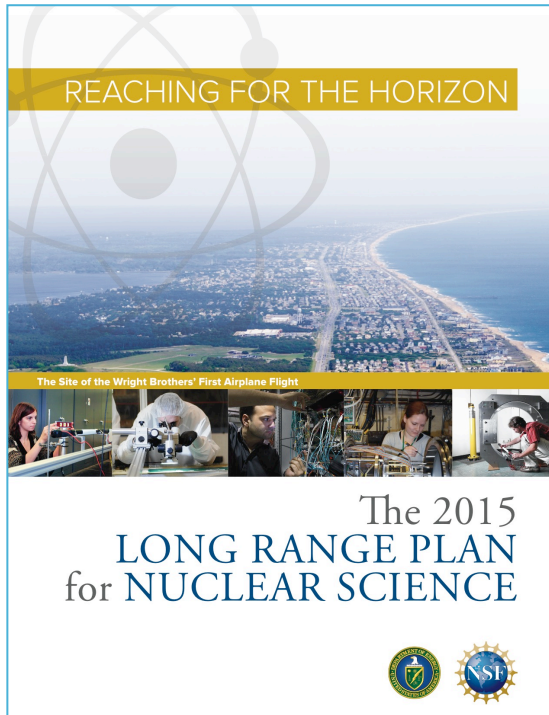


The 2015 LRP for Nuclear Science:

There are two central goals of measurements planned at RHIC, as it completes its scientific mission, and at the LHC: **(1) Probe the inner workings of QGP by resolving its properties at shorter and shorter length scales. The complementarity of the two facilities is essential to this goal, as is a state-of-the-art jet detector at RHIC, called sPHENIX. (2) Map the phase diagram of QCD with experiments planned at RHIC.**

(1) and (2), both directly mapped to RNC near and midterm plans

LRP 2015 Recommendation I and III



- *The upgraded RHIC facility provides unique capabilities that must be utilized to explore the properties and phases of quark and gluon matter in the high temperatures of the early universe and to explore the spin structure of the proton.*

We recommend a high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB.

RNC program directly reflects LRP recommendations I and III